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Back to the Bench
A Chemist's Guide to Returning to the Laboratory

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Back to the Bench: A Chemist's Guide to Returning to the Laboratory

During the last few months, the population of the world has gone from barely knowing anything about viruses to being armchair immunologists. Life in many countries, including the United States, changed in a short period of time with the intent of our focus on viruses, coronaviruses in particular.

A virus is an infectious agent that replicates inside living cells of another organism. Viruses are very small, ranging from 20 to 300 nanometers, which is smaller than the average cell.

The COVID-19 virus is a new virus, part of the Coronavirus family (Coronaviridae). COVID-19 and other coronaviruses have a membrane enveloping the capsid. These viruses are in the middle to large range of the virus size scale at around 100 nm. The coronavirus is an RNA virus meaning its genetic material is ribonucleic acid (RNA) rather than deoxyribonucleic acid (DNA). RNA viruses have a higher mutation rate than DNA viruses and are difficult to create vaccines to combat.

Viral Infections

Individuals who are shedding the virus are contagious. Some viruses have symptomatic shedding, other viruses (COVID-19) have asymptomatic shedding, or a silent infectious period where the individual is contagious for a longer period of time before, or if, symptoms occur. The timeline of an infection starts with the exposure of an uninfected individual to the virus. As the virus infects the host cells and replicates, there is a period of incubation where the virus is latent. At some point during incubation, the first infected host cells begin to shed virus particles and the infectious period begins. This period may or may not include symptoms (Figure 1).

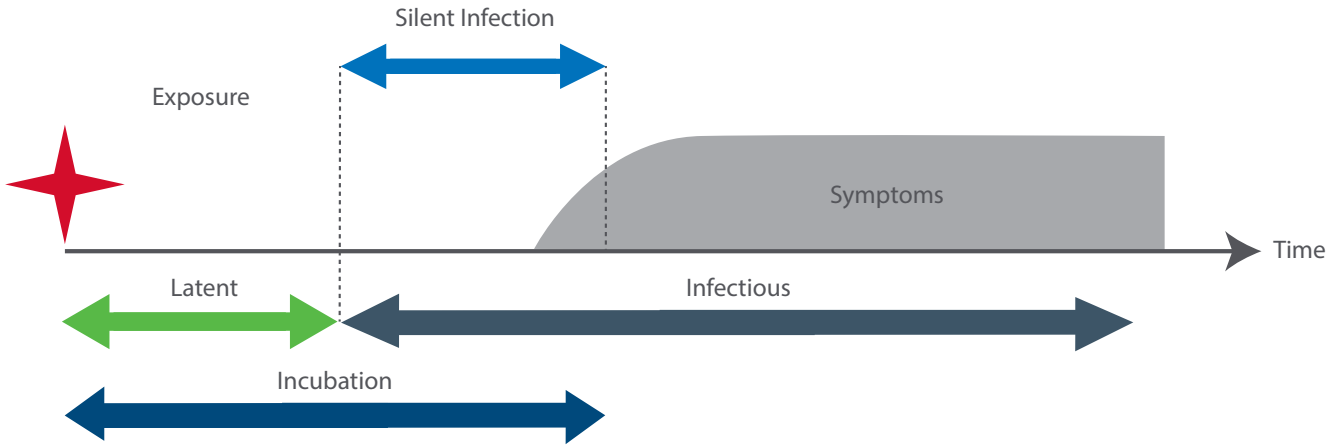

Figure 1. Viral Infection Disease Periods

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According to the CDC and OSHA, the most common symptoms of COVID-19 are persistent cough, shortness of breath or difficulty breathing. Additional reported symptoms range from loss of sense of smell to gastrointestinal problems. Currently identified symptoms are in Table 1. This list is not all-inclusive for all reported symptoms. Consult your healthcare provider for any other symptoms or changes that are severe.

Table 1. Reported symptoms of COVID-19 Viral Infection

Reported Symptoms of COVID-19 Viral Infection		
Cough	Chills	Loss of Taste
Shortness of Breath	Muscle Aches	Loss of Smell
Difficulty Breathing	Headache	Numbness in Extremities
Fever	Sore Throat	Rash on Extremities

Employers should screen (when legal and appropriate) their employees for COVID-19 symptoms prior to their return to work. Individuals may be asked to submit their temperature checks or subject to questioning regarding their general health, symptoms and potential exposure to ensure the safety of uninfected employees and to aid in contact tracing. Employers will need to work with their local regulations and human resources departments to comply with current federal, state and local laws.

Factors in viral spread include things like population density and mode of transmission, etc. The mode of transmission of a disease is the way in which a disease causing agent is transferred from an infected individual to another uninfected individual (direct or indirect physical contact). The COVID-19 virus has been shown to spread through direct contact with infected oral and nasal fluids and through indirect contact on surfaces where droplets of the virus can be deposited. The COVID-19 virus, at this time, appears to be primarily spread by person to person contact (direct) and, to a lesser extent, by indirect contact with contaminated surfaces.

The essential methods of dealing with an outbreak or pandemic is a multi-pronged attack to limit exposure by isolating those infected, keep risk of exposure to a minimum for the uninfected, practice good health and hygiene practices, develop and employ effective viricides to stop transmission and alleviate symptoms, and develop prophylactic measures such as vaccines to stop future emergence. The CDC has issued guidelines for limiting exposure for the general population (Figure 2) (cdc.gov/coronavirus/2019-ncov/prepare/prevention.html).

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KNOW HOW IT SPREADS		PROTECT YOURSELF				PROTECT OTHERS		
Person to person within 6 feet	Droplets	Wash hands > 20 seconds with soap and water	Hand sanitizer > 60% alcohol	Avoid touching face	Avoid close contact	Stay home when sick	Cover coughs and sneezes	Wear face mask when sick

Figure 2. CDC basic steps for protecting oneself and others from disease transmission (see appendices for available parts).

The first component is knowledge of the disease (i.e. symptoms, routes of exposure, health tracking) and limiting spread (i.e. work from home, social distancing and reduced groups). Checklists can be used by employers to make sure they are reducing exposure of their employees and workplaces to COVID-19 (Table 2).

Table 2. Employer personnel checklist for stopping employee exposure and spread of COVID-19

Personnel Checklist
Encourage sick employees to stay home
Encourage isolation for employees exposed to COVID-19 for recommended period > 14 days
Support work from home or telecommuting, if possible, to encourage social distancing
In-house employees conduct daily health checks (symptoms and temperature checks) (see appendices for parts)
Have an action plan for dealing with sick employees and COVID-19 exposure
Review policies with Human Resources to ensure compliance to public health policy and privacy requirements
Review government guidance documents (CDC, OSHA, etc.) for updates (see references)

The second line of defense is for all individuals and workplaces to practice behaviors to limit exposure that include cleaning and disinfection of common areas and good hygiene practices in the office and in the laboratory.

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Social Distancing in the Workplace and Laboratory

In the workplace, social distancing and not gathering in groups translates into several policies such as staggering work schedules and changing to shifts. Non-essential personnel can be asked to work from home. Some other policies can include stoppage of travel and in-person meetings. Meetings can be arranged by phone or online with our current technology. Contact should also be limited from outside vendors, sales people, visitors, and food delivery.

During times of crisis, it is imperative that managers of HR departments are given accurate contact information, schedules and locations of all employees for health and safety. Essential personnel should be issued all of the guidance and equipment to perform their functions legally and safely. Beyond personal protection equipment for the lab personnel, letters of essential work and travel documents should be supplied for the employees to display to authorities if requested.

Cleaning and Disinfecting

The COVID-19 virus can live from several hours to several days on various surfaces. The half-life of a virus is how long up to half of the virus initially deposited will remain viable and the viability is the amount of time in total viable virus particles can be detected (Table 3).

Table 3. COVID-19 persistence on surfaces

Surface	COVID-19 Viability (hours)	Half-Life (hours)
Aerosols	3	1.2
Copper	4	0.8
Cardboard	24	3.5
Stainless Steel	72	5.6
Plastic	72	6.8

The CDC recommends the development and maintenance of a general cleaning plan (Figure 3). General cleaning plans can be implemented for all areas including laboratories, but special consideration for some laboratory processes which may be sensitive to some cleaning materials or methods.

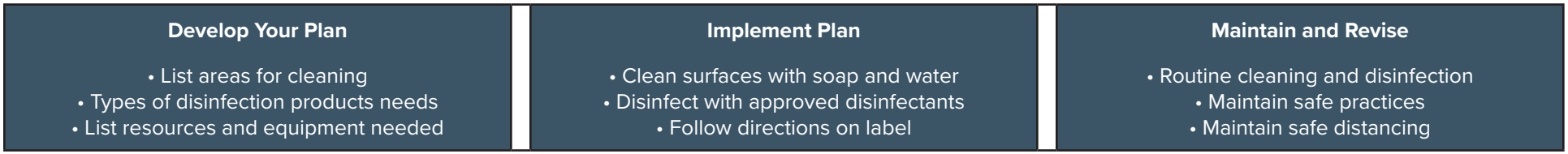

Figure 3. CDC Recommended Cleaning Plan

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The first step in the plan is identifying all of the areas for cleaning and listing resources needed. The next step for disinfection is general cleaning. Dust and dirt attract and collect particles of mold and viruses. The workplace must be cleaned from ceiling to floor to remove dirt and debris. Filters must be changed in hoods and environmental control systems. Trash must be removed and clutter discarded. After general cleaning, the process of disinfection can then occur using any number of products.

There are many commercial products for all types of settings from home to health care and laboratory. Most of these products have familiar active chemical agents such as alcohols, acids, chlorides, etc. The mode of action for these products is usually one of three processes:

1. Dehydration: where the virus or biological agent is dehydrated by the chemical and is rendered inactive.
2. Disruption: cell of capsule disruption by denaturing proteins or dissolving lipid capsules thereby spilling cell or viron contents out and drying them before they can replicate.
3. Genetic disruption: stoppage of genetic, protein or amino acid processes and inhibition of replication.

The EPA has published an extensive list of all of the commercial products for use in cleaning against viruses and COVID-19 and the appropriate cleaning times on their website: https://epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2. Table 4 summarizes the most common active ingredients and their suggested contact times that are dependent on the product, method of application and concentration. The EU has also provided guidance on agents that have been tested on viruses in the Coronavirus family with their concentrations for use (Table 5).

Table 4. Common active ingredients used in commercial disinfectants and their contact time for disinfection

Active Ingredients	**Average Suggested Contact Time** (Dependent on Concentration)
Citric Acid	5–10 minutes
Ethanol	1–5 minutes
Formaldehyde	5–10 minutes
Glutaraldehyde	5–10 minutes
Hydrochloric Acid	10 minutes
Hydrogen Peroxide	1–5 minutes
Iodine	10 minutes
Isopropanol	1–5 minutes
Ortho-phthalaldehyde	10 minutes

Peroxyacetic Acid	1–5 minutes
Phenolics	5–10 minutes
Quaternary Ammonium	5–10 minutes
Sodium Chlorite	5–10 minutes
Sodium Hypochlorite	1–10 minutes

Table 5. Concentration of disinfection agents tested against viruses in the family of Coronavirus (see appendices for parts)

Agent	Concentration
Benzalkonium Chloride	0.1%
Ethanol	70%
Formaldehyde	0.7%
Glutaraldehyde	2.0%
Isopropanol	50%
Povidone-iodine	10% (1% Iodine)
Sodium Chlorite	0.23%
Sodium Hypochlorite	0.05–0.5%

There are instructions on use and dilution of common laboratory chemicals such as ethanol, sodium hypochlorite, etc. on the disinfection pages of the CDC for healthcare settings cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html.

The common theme for all of these products, whether they are commercial products or laboratory produced disinfectants, is that the products must be applied and allowed to disinfect for a period of time before being wiped away. This time is called the dwell time or contact time. Surfaces must be wet to be effective.

There are also appropriate surfaces for each type of cleaner. The manufacturer should list all of the surfaces approved for the agent. Disinfectants will not work universally on all surfaces. No matter which method if cleaning is selected, it is important to create and maintain checklists to remind employees of common touch points in the laboratory and office. These touch points must be cleaned as if they were contaminated and include obvious candidates such as phones, keyboards and light switches, but also include less considered areas such as water fountain knobs, pens, scissors, laboratory spray bottles, etc. Figure 4 is a general summary of common touch points in an office and laboratory to be included in a checklist.

Laboratory Surfaces Checklist	
General Cleaning	**Laboratory Related**
Computers, Keyboards and Monitors	Instrument Computers
Power Buttons	Instrument Knobs
Doorknobs, Light Switches and Thermostats	Balance Buttons
Office and Cell Phones	Pipette Handles
Air Filters	Frequently Used Chemical Bottles
Desk	Hood Controls
Pens, Scissors, Staplers, Tape Dispensers	Spigots and Faucets
Copiers and Printers	

Figure 4. Common office and laboratory surfaces to be disinfected

Before cleaning and disinfecting an area, all porous materials such as paper, paper towels, etc. should be removed from the areas to be cleaned so as not to absorb chemicals. Select cleaning agents appropriate for the area to be cleaned with thought in mind as to the type of work that occurs in these areas and how that will be affected by these agents. If possible, airflow and hood flow should be increased to drive fumes away from work areas. Chemical odor traps can be used to absorb volatile chemical fumes. Hoods and sensitive areas should be decommissioned during cleaning and allow several hours for fumes to dissipate.

Multiple spot cleanings should be scheduled during a shift with a plan for more extensive cleaning on a periodic basis. Deep cleaning plans and services should be outlined in a cleaning plan upon an exposure within the laboratory. Personal cleaning and hygiene plans and expectations should be discussed or notices posted to remind everyone to keep a cleaning plan.

Hygiene Practices

One of the most important acts a person can do to reduce their exposure is to wash their hands for a minimum of twenty seconds with soap and water. Most soap compounds are composed of materials whose molecules have a dual nature. One end of the soap molecule is hydrophilic and binds easily to polar solvents such as water. The opposite end is lipophilic and binds to long hydrocarbon chains, proteins and lipids. The action of the soap and water together allows for viral particles to become bound to the soap's lipophilic structure and allows water to wash the particles away. The soap does need time in contact with the virus particles before being washed away with water. This reason is why it is suggested that a minimum of twenty seconds of hand washing is necessary. Many antibacterial agents are ineffective against viruses unless the agent contains more than 60% to 70% alcohol which will denature the virus membranes and kill the virus.

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Personal Protective Equipment

Laboratory employees are often familiar with common laboratory PPE but there are some differences in equipment and use that one often takes for granted as correct. Each type of PPE and equipment can have different ratings and use such as masks, respirators, gloves, etc. that are dependent on the function they are intended for in the laboratory.

There are some specialized PPE's that are only used in specific settings: items such as sticky mats, shoe covers and clean rooms stop the transfer of particles (dirt and otherwise) to and from locations. In chemistry laboratories, these items are used mostly to protect the laboratory from added contamination. In a hospital or healthcare setting, these items can also protect the environment from the transfer of contaminated particles outside a quarantined or contaminated area (see appendices for parts).

Respirators, face masks and face shields cover different parts of the face but generally cover the mouth and nose. Face shields offer the least amount of respiratory protection since they are only physical barriers to splashes and respiratory expulsions directed at the face. Respirators filter particles, chemicals and fumes depending on their specification using filtration chemicals or materials. Respirators are meant to protect the wearer from these agents and must be properly fitted and tested by a professional to ensure good seal and appropriateness for use. Face masks can also potentially be a tool for the filtration of particles depending on their rating. Fitted face masks are very different from the surgical masks being seen in pictures during this outbreak. All of the world organizations warn that a generic face mask is not a substitute for a fitted and regulated face mask or respirator.

During the COVID-19 pandemic, the use of N95 respirators is often called for and requested. These particle respirators trap up to 95% of particles. For more information, refer to CDC, OSHA, NIOSH, and ISO guidelines and instructions on selection and use of respirators and masks.

It is more common that chemists and other laboratory scientists use basic PPE such as goggles, glasses, gloves, and lab coats. All of these PPE items are needed for chemical protection but can also be used for protection against biological agents. As with the respirators, there are different classes of goggles, glasses and gloves that are dependent upon use.

Goggles and glasses protect the eyes from splashes and can be made from a multitude of materials resistant to a range of agents. Gloves as well can be made from a variety of materials which is important to understand since each type of glove has its own strengths and weaknesses. Many gloves are subject to issues of chemical or biological resistance, meaning not all materials are resistant to all agents and therefore offer limited protection (Table 6). Cole-Parmer offers an interactive tool on their website to find glove compatibility: www.coleparmer.com/safety-glove-chemical-compatibility.

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Table 6. Chemical resistance for glove materials against laboratory materials

Compound	Natural Rubber	Neoprene	Butyl	PVC	Nitrile
HCl 37%	3	3	4	3	3
Ammonium Hydroxide 70%	1	3	4	2	3
NaOH 70%	4	4	4	4	3
Aromatic Hydrocarbons	1	1	1	1	Varies
Methylene Chloride	1	1	1	1	2
Acetone	1	1	4	1	1
Ethanol	1	2	4	1	3
IPA	1	3	4	2	4
Methanol	1	1	4	1	1
Hydrogen Peroxide	4	2	4	3	4

1 = Not recommended; < 1 hour
2 = Fair; breakthrough at 1 hour
3 = Good; 4 hours
4 = Excellent; > 8 hours

The choice of the proper PPE is not the only factor in protection for the wearer. The matter in which PPE is put on and removed after use is important. Many laboratories or healthcare settings have isolation PPE procedures for strict quarantine and contamination control. Smaller commercial laboratories with lower risk for infection often have simple, if any, procedures for proper PPE use. These are some tips to help use PPE efficiently.

Gloves, as was stated previously, should be of a compatible material for the purpose. If a laboratory technician is cleaning for COVID-19 using alcohols such as ethanol, they should not be using latex or other incompatible gloves that might start to become permeable and expose the individual to contaminants, solvents or other agents. Gloves must fit snugly but not so tight that they stretch and become compromised more quickly during use. Gloves should also not gap at the fingers. After gloves are contaminated, they can be removed by pulling one glove off with the still gloved hand and then, using the inside portion of the glove to remove the second glove, folding them into each other so the glove disposal packet has the contaminated or exposed areas contained inside the packet.

Lab coats should fit properly and button. The cuffs should not hang down into the work area nor should the cuffs be too short to not cover the tops of the gloves when worn. Pockets should not contain items that cannot be exposed to contamination or infection such as personal phones. Lab coats should be changed frequently. The removal of the lab coat is similar to the gloves where the sleeves are removed inside out and the outside is folded inside to contain the contaminated area.

In the event of a known viral exposure, all PPE items and trash should be isolated from the common waste stream and disposed of in a separate location.

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Reopening Business Workplaces

During this epidemic, some businesses were forced to shut down physical locations for an extended period of time. A complete shutdown of a workplace and the subsequent return to business can have its own set of challenges and guidelines. Employers need to create and update plans specific to their workspaces. These plans must identify all areas and job tasks with their corresponding risk to COVID-19 exposure and include plans to reduce exposure.

A building that has undergone complete shutdown should be examined for engineering and health issues which may arise during startup. These issues can include ventilation, plumbing and other systems that can affect employee safety and health.

Building systems (such as HVAC, plumbing, etc.) will need monitoring, cleaning and adjustment during a building restart. These activities can include increasing ventilation, monitoring indoor air quality, and opening outdoor air dampers to reduce recirculation. See Figure 5 for more actions for returning to the physical workspace, and refer to the ASHRAE "Guidance for Building Operations During the COVID-19 Pandemic" and the OSHA guidelines listed in the references for more information on building operations after COVID-19.

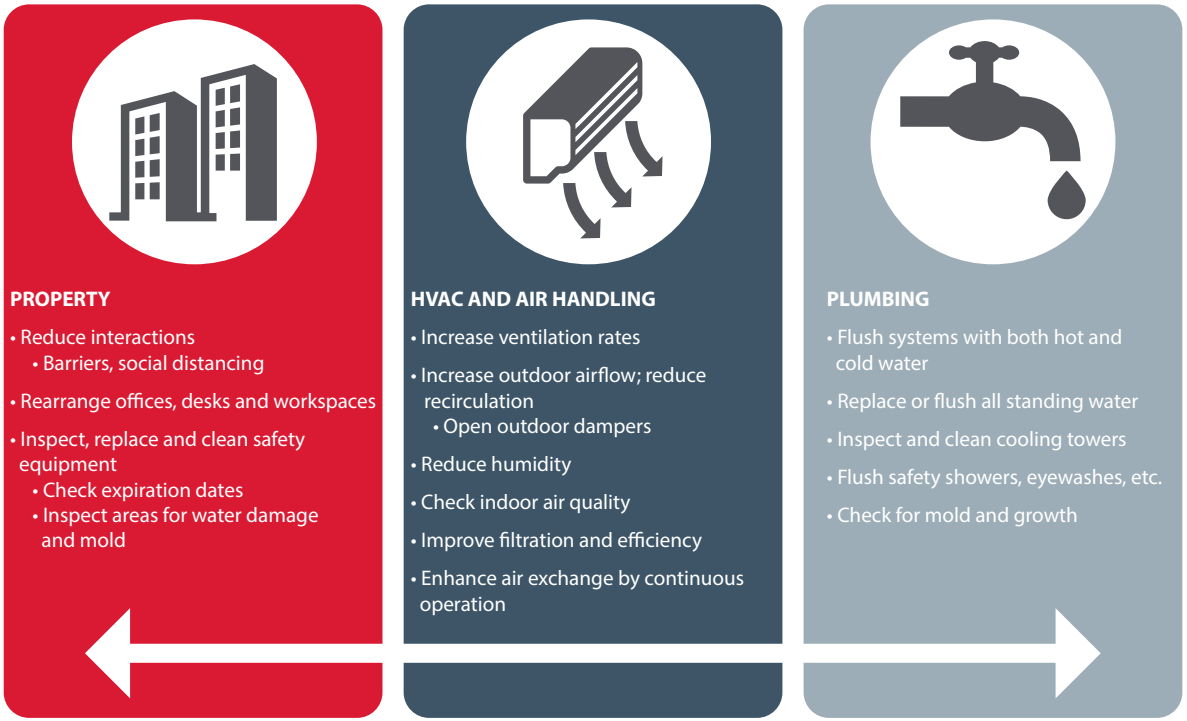

Figure 5. Actions in the workplace for building and reopening

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Laboratory Personnel Reductions and Automation

Many laboratories and other types of process facilities are currently facing issues of staffing. In some cases, staffing has been significantly reduced in the laboratory or is not conducive to efficient workflow. In these situations, some of the physical burden of laboratory processes and sample preparation can be aided by a switch to automated or semi-automated processes and equipment. Laboratories can adopt or upgrade their laboratory automation to aid in workforce gaps.

The way to determine areas needing automation is often to ask the employees. Most team members have ideas how to automate processes which are:

1. Repetitive
2. Labor and time intensive
3. Need high reproducibility
4. Require accuracy

Sample preparation is one area that can be very labor and time intensive. In sample preparation, use of high-throughput laboratory equipment can speed up a process or compensate for reduced workforce. Automated sample processing equipment such as laboratory grinders and mills can quickly and efficiently process dozens of samples in the time it takes to manually process and grind one sample (see appendices for sample automation equipment and parts).

Other laboratory automations can involve using or upgrading autosamplers for instruments. Utilizing batch processing for samples and data can streamline throughput as well. Laboratories often have unique challenges and many laboratory supply companies such as Cole-Parmer have practical tools to increase efficiency and throughput.

Special Considerations for Laboratory Startup

Laboratories have special needs when it comes to restarting its workflow. All the concerns of the physical environment, the air handling systems, plumbing, etc. in a normal workspace are compounded by the worries of laboratory process contamination due to the shutdown of systems. There are many sources of contamination (COVID-19 notwithstanding) in laboratories during normal operations that are only heightened after a shutdown.

Dust collects quickly in unused areas and can be a large source of chemical and physical contamination. Surface contaminants can be found in dust and rust on shelves, equipment and furniture. Dust contains many different earth elements, such as sodium, calcium, magnesium, manganese, silicon, aluminum, and titanium. Dust can also contain elements of human activities, such as nickel, lead, zinc, copper, and arsenic and organic compounds like pesticides, persistent organic pollutants (POP), and phthalates. The dust and rust

particles can contaminate open containers in the lab or enter containers by charge transfer from friction by the triboelectric effect. The triboelectric effect or triboelectric charging is when materials become charged after coming into contact with a second material creating friction. The most common example of this effect is seen when hair sticks to a plastic comb after a static charge is created.

The polarity and the strength of the electrical charge are dependent upon the type of material and other physical characteristics. Many materials in the lab have strong positive or negative triboelectric charges as seen in Figure 6. In the laboratory, materials like dust, air, skin, and lead have extreme positive charges and can be attracted to the strongly negative charge of PTFE or other plastic bottles when the bottle is opened and creates friction inducing charge.

Figure 6. Triboelectric charge potential of common materials and particles in the laboratory

Dust and other contaminants can spread through the laboratory by the environmental systems so all of the policies for changing filters and increasing air flow must be strictly observed in the reopening of a laboratory.

Just as water and plumbing is of concern in the reopening of the workplace, it is very important in the restarting of a laboratory. Water is one of the most basic, yet most essential laboratory components. After an extended shut down, there are two primary concerns for water systems: contamination and quality.

All standing sources of water must be drained, discarded, sanitized, and refilled. These standing water sources include distilled water taps, carboys, mobile phase bottles, cleaning supplies, and water baths. Studies by SPEX CertiPrep, available at spexcertiprep.com/knowledge-base, have shown increased levels of phthalates and elemental contamination from standing or stationary water sources that could contaminate critical experiments and testing.

There are many types, grades and intended uses for water. Water quality can be compromised if water polishing systems are not properly flushed and polishing agents replaced. Poor quality water can cause a host of problems from creating deposits in labware to inadvertently increasing a target element or element concentration in a solution.

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The actual type of water produced by a commercial laboratory water filtration system can vary in pH, solutes, and soluble silica. Critical analytical processes should always require a minimum quality of ASTM Type I Water. All trace analysis standards, dilutions, dissolutions, extractions, and digestions should be conducted with the highest purity water. Analysts who use certified reference materials (CRMs) and perform quantitative analysis need to use quality water in order not to contaminate their CRMs, standards and samples with poor quality water (see appendices for blank water parts).

High purity water is often achieved in several stages in multiple processes which remove physically and chemically potential contaminating substances. Municipal water supplies often test their own water sources on an annual basis, but that does not mean it is applicable for use in laboratory applications. Municipal water can become contaminated from its distribution point, especially when left static sitting in pipes, tubing and hoses. Water left stationary in a laboratory water system can be exposed to leaching of elements and compounds from the piping and hoses.

After a prolonged shutdown, an inventory must be done of all chemical components including solvents, reagents, solid chemicals, gases and standards to determine expiration date, safety and stability. Solvents and other volatile chemicals that were opened prior to a prolonged period of a shutdown should be discarded since their properties and contamination levels may have changed,

Frozen or refrigerated materials that may have changed temperature in unmonitored refrigerators or freezers or have been subject to power fluctuations should be questioned or discarded. Standards and preparations opened or created before a shutdown should be scrutinized since evaporation or chemical changes may have occurred with prolonged disuse or environmental changes, such as lack of heating or cooling in laboratories. Table 7 contains a list of general items to be checked in the laboratory upon startup after a prolonged shutdown.

Table 7. General laboratory startup checklist

Prior to Lab Entry
Check with engineering regarding safety of running plumbing and HVAC
Check phone system is operational
Log your presence in laboratory with appropriate supervisors
Check for appropriate supplies and PPE
Inspect environment for evidence of mold or water damage

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General Laboratory
After engineering has cleared HVAC system, set laboratory temperature to ambient conditions
Increase hood speed
Open water taps and spigots and flush
Flush all laboratory water sources
Replace water polishing components: sanitizers, filters, chemicals
Flush all standing liquids and water: baths, DI sources, solvent bottles, mobile phases, cleaning supplies
Separate water baths and other items needing disinfection
Check water based safety components: eyewash, shower
Check chemical spill kits for expiration
Check fire extinguishers for expiration
Check emergency lights and other safety items
Start computer systems
Chemical Inventory
Check temperature data loggers for freezers and refrigerators: flag areas where temperature was not controlled and items will be discarded
Discard open solvents
Check expiration dates: standards, reagents, solvents, solids, etc.
Discard materials subject to environmental changes beyond normal conditions
Final Points
Change hood filters
Gather and discard all debris
Gather and safely dispose of contaminated cleaning supplies
Dispose of expired chemicals, standards, samples, etc.
Start list or reorder chemicals, standards and supplies that are expired or no longer stable

Restarting Laboratory Apparatus and Instruments

If the laboratory performs analytical testing, it will require an added level of diligence to restart the laboratory, restart its function and restore analytical conditions. The area around the instruments and the instruments themselves must be inspected for damage, dust or mold. Chemicals and gases linked or used by the instrument must be discarded and replaced. Consumables must be replaced and areas of maintenance and cleaning must be performed prior to operation. Table 8 contains a checklist of general points for instrument startup within a laboratory.

Table 8. Instrument startup checklist (see appendices for parts)

Instrument Startup
Check instruments for physical signs of problems
Change fittings, seals and filters if prone to drying out or leakage
Change consumable parts such as septum, lines, tubing, etc.
Check instrument liquids and gases for expiration and proper connections
Replace gases
Replace and remake eluents, buffers, mobile phases, etc.
Perform cleaning and maintenance of instrument systems
Open fresh standards or buffers; bring to room temperature
Refill calibration or tuning solutions (see appendices for parts)
Refill rinse vials
Tune or calibrate instruments and equipment
Instrument Data Validation
Prepare fresh internal standards (see appendices for parts)
Run LOD, LOQ studies (see appendices for parts)
Run blank studies (see appendices for parts)
Requalify instrument if needed

Laboratories should follow a general regime of three runs each of wash/rinse runs, blank runs and sample runs, as well as single runs of sample plus spike, and standard or spike runs without a sample to use as a control solution to evaluate recovery. Analysts must realize that the cleanliness and accuracy of their procedures, equipment and dilutions affect the quality of the standards and samples.

Conclusions

As businesses begin to return to operation, laboratories which may have been forced to shut down during the pandemic, are now being asked to reopen with a new level of concern for not only chemical contamination but viral contamination. During this time of heightened anxiety, it is good to know most common laboratory procedures used to keep scientists safe from chemical exposures also work well for limiting biological exposures. It is important to keep in mind all of the advice given by governmental agencies for our protection, but also develop a plan and set of resources to return to business in the office and in the laboratory.

The attached appendices contain checklist items and lists of common supplies to help restore your workspace to functioning order in this new reality of COVID-19.

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Appendix I: For ICP, ICP-MS Instrumentation

Blanks: Blanks are for establishing the baseline background noise and can be used in qualification of LOD. CCB, Continuing Calibration Blank, is for periodically checking/monitoring contamination levels during the analysis after running the rinse solution which is for cleaning out the instrument and sample uptake system after each measurement.

CLBLK-H2O	ICP-MS	Blank
CLBLK-HCL	ICP-MS	Blank
CLBLK-HNO3	ICP-MS	Blank
PLBLK-H2O	ICP	Blank
PLBLK-HCL	ICP	Blank
PLBLK-HNO3	ICP	Blank

Calibration/Verification: Calibration and verification standards allow you to calibrate or verify the calibration of an instrument usually to EPA method standards. The CCV, Continuing Calibration Verification, is often required to be independent of the calibration standard. For example, an alternate lot or second source standard.

CL-CAL-1	ICP-MS	Calibration/Verification
CL-CAL-1A	ICP-MS	Calibration/Verification
CL-CAL-2	ICP-MS	Calibration/Verification
CL-CAL-2A	ICP-MS	Calibration/Verification
CL-CAL-3	ICP-MS	Calibration/Verification
CL-ICV-1	ICP-MS	Calibration/Verification
CL-ICV-2	ICP-MS	Calibration/Verification
CL-ICV-3	ICP-MS	Calibration/Verification
ICAL-1	ICP & ICP-MS	Calibration/Verification
ICAL-2	ICP & ICP-MS	Calibration/Verification
ICAL-3	ICP & ICP-MS	Calibration/Verification
ICAL-4A	ICP & ICP-MS	Calibration/Verification
MIX-STD1-100	ICP	Calibration/Verification
MIXSTD1A-100	ICP	Calibration/Verification
MIXSTD1C-100	ICP	Calibration/Verification
MIXSTD2-100	ICP	Calibration/Verification

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MIXSTD2A-100	ICP	Calibration/Verification
MIXSTD3-100	ICP	Calibration/Verification
MIXSTD3A-100	ICP	Calibration/Verification
MIXSTD4-100	ICP	Calibration/Verification
MIXSTD4A-100	ICP	Calibration/Verification
MXSTD4A-100N	ICP	Calibration/Verification
MIXSTD5-100	ICP	Calibration/Verification
MIXSTD5A-100	ICP	Calibration/Verification

Check Standard: Check standards are usually an instrument-targeted standard which monitor drift and changes during operation and are run at intervals to monitor changes.

CL-ICS-1	ICP-MS	Check Standard
CL-ICS-3	ICP-MS	Check Standard
CL-ICS-4	ICP-MS	Check Standard
CL-ICS-5	ICP-MS	Check Standard

Interference: Interference standards are run to check for the effect if interference elements on the system and target analytes. They could also be used to establish (rather than just check) correction factors, sometimes called ICE for Interference Correction Equations or IEC for Inter-Element Correction.

CL-INT-A1	ICP-MS	Interference
CL-INT-A2	ICP-MS	Interference
CL-INT-A3	ICP-MS	Interference
CL-INT-B1	ICP-MS	Interference
CL-INT-B2	ICP-MS	Interference
CL-INT-B3	ICP-MS	Interference
CL-INT-B3N	ICP-MS	Interference

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Internal Standard: An Internal Standard is a standard which is added to all samples, blanks and external standards to correct for instrument variation between runs or over time. These standards allow one to correct for difference between runs due to instrument variances.

CL-ISM1-100	ICP-MS	Internal Standard
CL-ISM2-100	ICP-MS	Internal Standard
CLISS-1	ICP-MS	Internal Standard
CLISS-2	ICP-MS	Internal Standard

Memory Test: To identify or confirm the maximum concentration of an analyte that does not cause a memory effect greater than the contract required detection (CRDL). The test solutions are not analyzed directly; equal volumes of the two are mixed and then introduced into the instrument for a normal sample exposure time. A blank is then run to confirm that all analyte memory effects are below the CRDL.

CL-MEM-1	ICP-MS	Memory Test
CL-MEM-2	ICP-MS	Memory Test

Tune Solutions: Solutions containing elements or analytes designated by an instrument manufacturer for a tuning procedure used to keep the instrument in overall calibration and run condition or peak performance condition.

CL-TUNE-1	ICP-MS	Tune Solution
CL-TUNE-2	ICP-MS	Tune Solution
CL-TUNE-3	ICP-MS	Tune Solution
CL-TUNE-4	ICP-MS	Tune Solution

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Appendix II: For GC/MS, HPLC, LC/MS Instrumentation

Calibration/Verification: Calibration and verification standards allow you to calibrate or verify the calibration of an instrument usually to EPA method standards. The CCV, Continuing Calibration Verification, is often required to be independent of the calibration standard. For example, an alternate lot or second source standard.

5242-VCX-200	GC/MS	Calibration/Verification	EPA 524.2
5312-A	GC/MS	Calibration/Verification	EPA 531.2
60-BIG-MIX	GC/MS	Calibration/Verification	EPA 524.2, EPA 624, EPA 8260B
76-BIG-MIX	GC/MS	Calibration/Verification	EPA 625, EPA 8270C, EPA CLP Semi-VOA
8015-OX	GC/MS	Calibration/Verification	EPA 8015
8082-C	GC/MS	Calibration/Verification	EPA 8082
8082-IC	GC/MS	Calibration/Verification	EPA 8082
8260-A1	GC/MS	Calibration/Verification	EPA 8240B, 8260B
8260-BIG-MIX	GC/MS	Calibration/Verification	
BIG-BN-2	GC/MS	Calibration/Verification	EPA 625, EPA 8270C, EPA 8310
CLPP-LLA	GC/MS	Calibration/Verification	EPA 8310
ECS-K-050	GC/MS	Calibration/Verification	
ECS-KN-050	GC/MS	Calibration/Verification	
NJDEP-EPH-ALCS	GC/MS	Calibration/Verification	NJDEP OQA-QAM-025-02/8
NJDEP-EPH-ARCS	GC/MS	Calibration/Verification	NJDEP OQA-QAM-025-02/8

Internal Standard: An Internal Standard is a standard which is added to all samples, blanks and external standards to correct for instrument variation between runs or over time. These standards allow one to correct for difference between runs due to instrument variances.

5022-I	GC/MS	Internal Standard	EPA 502.2, EPA 8021/8021A/8021B
507-I	GC/MS	Internal Standard	EPA 507
508-I	GC/MS	Internal Standard	EPA 508
5242-I	GC/MS	Internal Standard	EPA 524.2
5243-I	GC/MS	Internal Standard	EPA 542.3
5252-I	GC/MS	Internal Standard	EPA 525.2
531-I	GC/MS	Internal Standard	EPA 531.1

5481-IS	GC/MS	Internal Standard	EPA 548.1
548-IS	GC/MS	Internal Standard	EPA 548
550-I	GC/MS	Internal Standard	EPA 550/550.1
5511-I	GC/MS	Internal Standard	EPA 551.1
602-I	GC/MS	Internal Standard	EPA 602
624-I	GC/MS	Internal Standard	EPA 624
8015B-I	GC/MS	Internal Standard	EPA 8015B
8260A-I	GC/MS	Internal Standard	EPA 8260B
8260A-S	GC/MS	Internal Standard	EPA 8260B
8260B-I	GC/MS	Internal Standard	EPA 8240B, EPA 8260B
8260-I	GC/MS	Internal Standard	EPA 8260B
CLPS-I	GC/MS	Internal Standard	EPA 625, EPA 8270C, EPA 8310
CLPS-I5	GC/MS	Internal Standard	EPA 8270C, EPA CLP Semi-VOA
CLPS-I90	GC/MS	Internal Standard	EPA 625, EPA 8310
CLPV-I2	GC/MS	Internal Standard	EPA 8260B, EPA CLP VOA
CLPV-LC-A	GC/MS	Internal Standard	EPA 8260B, EPA CLP VOA
CLPV-MH	GC/MS	Internal Standard	EPA 8240B, EPA 8310
CLPV-SH	GC/MS	Internal Standard	EPA 8310

Tune Solution: Solutions designated by an instrument manufacturer for a tuning procedure used to keep the instrument in overall calibration and run conditions or peak performance condition.

CLPS-T	GC/MS	Tune Solution	EPA 548.1, EPA 625, EPA 8270C, EPA 8310
CLPS-T4	GC/MS	Tune Solution	EPA 625, EPA 8270C, EPA 8310
CLPV-T	GC/MS	Tune Solution	EPA 8240B, EPA 8310
CLPV-TH	GC/MS	Tune Solution	EPA 524.2, EPA 8240B, EPA 8310
ECS-K-TUNE	GC/MS	Tune Solution	EPA 8270

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Multipurpose Check Standards: General use standards that can be used as several different types of standards from a check standard, internal standard to a quality control standard.

S-2725	HPLC/LC/MS	Multipurpose Check Standard
S-2728	HPLC/LC/MS	Multipurpose Check Standard
S-2730	HPLC/LC/MS	Multipurpose Check Standard
S-3249	HPLC/LC/MS	Multipurpose Check Standard
S-705	HPLC/LC/MS	Multipurpose Check Standard

Appendix III: For pH Meters

pH Buffer Solutions: For calibration and quality control checks.

PH-BUFF2-500	pH	Buffer/Check Solution
PH-BUFF3-500	pH	Buffer/Check Solution
PH-BUFF4-500	pH	Buffer/Check Solution
PH-BUFF5-500	pH	Buffer/Check Solution
PH-BUFF6-500	pH	Buffer/Check Solution
PH-BUFF7-500	pH	Buffer/Check Solution
PH-BUFF8-500	pH	Buffer/Check Solution
PH-BUFF9-500	pH	Buffer/Check Solution
PH-BUFF10-500	pH	Buffer/Check Solution
PH-BUFF11-500	pH	Buffer/Check Solution
PH-BUFF12-500	pH	Buffer/Check Solution

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Appendix IV: For Conductivity Instruments

Conductivity Standards: For calibration and quality control checks.

4065OT	Conductivity and TDS	Batch-Tested: 10 µS, 500 mL
4066OT	Conductivity and TDS	Batch-Tested: 100 µS, 500 mL
4067OT	Conductivity and TDS	Batch-Tested: 1000 µS, 500 mL
4068OT	Conductivity and TDS	Batch-Tested: 10,000 µS, 500 mL
4069OT	Conductivity and TDS	Batch-Tested: 100,000 µS, 500 mL
4161OT	Conductivity and TDS	Batch-Tested: 150,000 µS, 500 mL
4162OT	Conductivity and TDS	Batch-Tested: 200,000 µS, 500 mL
4172OT	Conductivity and TDS	Assortment: 6 x 100 mL Vials
4173OT	Conductivity and TDS	Batch-Tested: 1413 µS, 500 mL
4174OT	Conductivity and TDS	1413 µS, 6 x 100 mL Vials
4175OT	Conductivity and TDS	10 µS, 6 x 100 mL Vials
4176OT	Conductivity and TDS	100 µS, 6 x 100 mL Vials
4177OT	Conductivity and TDS	1000 µS, 6 x 100 mL Vials
4178OT	Conductivity and TDS	10,000 µS, 6 x 100 mL Vials
4179OT	Conductivity and TDS	100,000 µS, 6 x 100 mL Vials
4270OT	Conductivity and TDS	Batch-Tested: 5 µS, 500 mL
4271OT	Conductivity and TDS	5 µS, 6 x 100 mL Vials
4274OT	Conductivity and TDS	Batch-Tested: 1 µS; 500 mL
4580OT	Conductivity and TDS	150,000 µS, 6 x 100 mL Vials
4581OT	Conductivity and TDS	200,000 µS, 6 x 100 mL Vials

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Appendix V: For Solvents

88400-48	Solution	4000 mL	Isopropanol, 70% (v/v) Aqueous Solution
88405-66	ACS	1000 mL	Isopropyl Alcohol (IPA), ACS Grade
88405-69	ACS	4000 mL	Isopropyl Alcohol (IPA), ACS Grade
88400-66	ACS, Absolute	4000 mL	Reagent Alcohol, ACS Reagent Grade, Anhydrous, Absolute
88406-18	HPLC	1000 mL	Acetone, HPLC Grade
88406-19	HPLC	4000 mL	Acetone, HPLC Grade
88406-16	ACS	4000 mL	Acetone, ACS Grade, Amber Glass Bottle
88406-12	ACS	1000 mL	Acetone, ACS Grade, Amber Glass Bottle
88401-41	HPLC	4000 mL	Methanol HPLC, Amber Glass
88405-93	HPLC	1000 mL	Methanol, HPLC Grade
88405-44	HPLC	1000 mL	Acetonitrile, HPLC Grade
88405-45	HPLC	4000 mL	Acetonitrile, HPLC Grade
88405-51	ACS	4000 mL	Ethyl Acetate, ACS Grade

Appendix VI: For Personal Care

4486NN	Infrared Forehead Thermometer
78900-47	80% Alcohol Hand Sanitizer - 1 Gallon
78900-48	80% Alcohol Hand Sanitizer - 8 oz Bottle with Spray Cap
78900-49	80% Alcohol Hand Sanitizer - 8 oz Bottle with Spray Cap (Case of 24)
IWT-IPA70-CW66	LabExact® Cotton Cloth 70% IPA (Isopropyl Alcohol) Wipes
78900-46	Disposable Face Shield with Nylon Strap and Foam Padding

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Appendix VII: Lab Equipment

Short On Staff? We've Got You Covered.

With the workload constantly increasing in laboratories, tools to automate manual processes are often very welcome. With this in mind, Spex SamplePrep offers a range of sample preparation equipment designed to increase throughput, ensure reproducibility and minimize cross contamination. Our cryogenic mills, homogenizers, ball mills, grinders, fusion fluxers and pellet presses are backed by exceptional service and applications expertise. For more information please visit www.spexsampleprep.com.

1200	1200 GenoLyte Mini Homogenizer
2010	2010 Geno/Grinder High Throughput Homogenizer
1600	1600 MiniG Compact Homogenizer
6775	6775 Freezer/Mill - Automated Cryogenic Mill - 0.1-5 g (single chamber)
6875	6875 Freezer/Mill - Automated Cryogenic Mill - 0.1-100 g (single chamber)
6875D	6875D Freezer/Mill - 0.1-100 g per chamber (dual chamber)
8000M	8000M Mixer/Mill - High Energy Ball Mill - 0.5-10 g (single clamp)
8000D	8000D Mixer/Mill - High Energy Ball Mill - 0.5-10 g per vial (dual clamp)
8530	8530 Shatterbox Ring and Puck Mill
3636	3636 X-Press 35 Ton Lab Press
X-300	Katanax X-300 X-Fluxer Electric Fusion Fluxer - fuses up to 15 samples per hour
X-600	Katanax X-600 X-Fluxer Electric Fusion Fluxer - fuses up to 30 samples per hour

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